MERCURY COMPOUNDS

Mercury compounds are federal hazardous air pollutants and were identified as toxic air contaminants in April 1993 under AB 2728.

CAS Registry Numbers:	Mercury 7439-97-6	Hg
	Mercuric chloride 7487-94-7	$HgCl_2$
	Methyl mercury 22967-92-6	CH_3Hg
Molecular Formulas:	Hg	
	Cl_2Hg	
	CH_3Hg	

Three of the numerous mercury compounds are mentioned here. Many are explosively unstable or undergo hazardous reactions. When heated to decomposition, they emit highly toxic fumes of mercury (Sax, 1989).

Elemental mercury is an odorless, silver white, very heavy, mobile, liquid metal, which is slightly volatile at ordinary temperatures. Solid mercury is tin-white, ductile, and malleable. Pure mercury does not tarnish on exposure to ordinary temperatures of air, and forms alloys with most metals, except iron. It combines with sulfur at ordinary temperatures, and reacts with nitric and hot sulfuric acid but not with dilute hydrochloric acid or alkalies (Merck, 1989). It is insoluble in water, alcohol, and ether but soluble in lipids. Mercury has high surface tension and electrical conductivity (Sax, 1987).

Mercuric chloride occurs as odorless, white crystals or powder. It is slightly volatile at ordinary temperatures, and appreciably volatile at 100 ^{o}C. It is soluble in water, alcohol, ether, pyridine, glycerol, and acetic acid and is incompatible with some formates, sulfur and phosphorus compounds, proteins, alkalies, ammonia, and metals (Merck, 1989).

Methyl mercury is a volatile, colorless liquid which is easily soluble in ether and alcohol, and insoluble in water (Merck, 1989).

Physical Properties of Mercury and Mercury Compounds

Synonyms: Mercury: quicksilver; mercury liquid, vapor, salts; hydrargyrum
Methyl Mercury: dimethylmercury
Mercuric Chloride: mercury (II) chloride; mercury bichloride; corrosive sublimate; mercury perchloride

	Mercury	Mercuric Chloride	Methyl Mercury
Valences:	1,2		
Atomic Number:	80		
Atomic Weight:	200.59		
Molecular Weight:		271.52	230.66
Boiling Point:	356.72 ºC	303 ºC	92 ºC
Melting Point:	-38.87 ºC	277 ºC	
Density/Specific Gravity:	13.53 at 25 ºC	5.4 at 25 ºC	3.18 at 20 ºC
Vapor Pressure:	2×10^{-3} mm at 25 ºC		
Heat of Vaporization:	14.65 kcal/mole at 25 ºC		
Conversion Factor:	1 ppm = 8.2 mg/m^3 (Elemental Mercury)		
	1 ppm = 11.1 mg/m^3 (Mercuric Chloride)		
	1 ppm = 9.43 mg/m^3 (Methyl Mercury)		

(Merck, 1989; Sax, 1989; U.S. EPA, 1994a)

SOURCES AND EMISSIONS

A. Sources

Mercury is used in measuring devices (barometers, thermometers, hydrometers, and pyrometers), the manufacture of dry cell batteries, fluorescent light bulbs, mercury salts, mirrors, agricultural poisons, antifouling paint, electrical apparatus, mercury vapor and arc lamps, and dental amalgams. It is also used in the electrolytic preparation of chlorine and caustic soda, as a catalyst in the oxidation of organic compounds, in extracting gold and silver from ores, in pharmaceuticals, and in mercury boilers (Merck, 1989; HSDB, 1991). The primary stationary sources that have reported emissions of mercury in California are electrical services, hydraulic cement manufacturing sites, and petroleum production facilities (ARB, 1997b).

Mercuric chloride is used in the manufacture of calomel, disinfectants, chemical reagents, metallurgy, tanning, as a catalyst for vinyl chloride, in embalming, as an intensifier in photography, in electroplating, and to free gold from lead. It is also used as an inorganic reagent (Merck, 1989). The primary stationary sources that have reported emissions of mercuric chloride in California are manufacturers of fabricated metal products, and nursing and personal care services (ARB, 1997b).

B. Emissions

The total emissions of mercury and mercury compounds from stationary sources in California are estimated to be at least 9,900 pounds per year, based on data reported under the Air Toxics "Hot Spots" Program (AB 2588). The total emissions of mercuric chloride from stationary sources in California are estimated to be at least 49 pounds per year (ARB, 1997b).

C. Natural Occurrence

Mercury is found in the earth's crust at 0.5 parts per million (Merck, 1989). It is found in rock and ores such as limestone, calcareous shales, sandstone, serpentine, chert andesite, basalt and rhyolite. It is recovered primarily from cinnabar although elemental mercury occurs in other ores. Fossil fuels such as coal, crude petroleum, hydrocarbons, and asphalts can contain mercury as well as volcanoes and hot springs (HSDB, 1991). Mercury is released into the air by outgassing of soil, transpiration, and decay of vegetation.

AMBIENT CONCENTRATIONS

Mercury and its species are routinely monitored by the statewide Air Resources Board air toxics monitoring network. The network's mean concentration of mercury and its species from January 1996 to December 1996 is estimated to be 1.6 nanograms per cubic meter (ng/m^3) (ARB, 1997c).

The United States Environmental Protection Agency (U.S. EPA) has compiled ambient concentration data for mercury from two study areas throughout the United States for 1988 and 1989. Information from these data showed an overall mean concentration of 5.8 ng/m^3 (U.S. EPA, 1993a).

INDOOR SOURCES AND CONCENTRATIONS

In a field study conducted in southern California, investigators collected particles (PM_{10}) inside 178 homes and analyzed the particle samples for selected elements, including mercury. Two consecutive 12-hour samples were collected inside and immediately outside each home. Mercury was present in measurable amounts in less that 10 percent of the samples (Clayton et al., 1993).

ATMOSPHERIC PERSISTENCE

Elemental mercury, Hg, exists almost totally in the gas phase in the atmosphere, as does methyl mercury (Iverfeldt, 1991). Inorganic mercury compounds are particle-associated in the atmosphere (Iverfeldt, 1991), and hence subject to wet and dry deposition. The average half-life and lifetime for particles and particle-associated chemicals in the troposphere is estimated to be about 3.5 to 10 days and 5 to 15 days, respectively (Balkanski et al., 1993; Atkinson, 1995).

Elemental gas-phase mercury has been shown to react with O_3, leading to a calculated half-life and lifetime of mercury due to reaction with O_3 of 3.8 days and 5.5 days, respectively, for an average O_3 concentration of 7×10^{11} molecules per cm^3 (30 parts per billion). Other potential reactions of elemental mercury are poorly understood (Schroeder et al., 1991).

AB 2588 RISK ASSESSMENT INFORMATION

The Office of Environmental Health Hazard Assessment reviews risk assessments submitted under the Air Toxics "Hot Spots" Program (AB 2588). Of the risk assessments reviewed as of April 1996, mercury contributed to the total cancer risk in 1 of the approximately 550 risk assessments reporting a total cancer risk equal to or greater than 1 in 1 million. Mercury also contributed to the total cancer risk in 1 of the approximately 130 risk assessments reporting a total cancer risk equal to or greater than 10 in 1 million (OEHHA, 1996a).

For non-cancer health effects, mercury contributed to the total hazard index in 16 of the approximately 89 risk assessments reporting a total chronic hazard index greater than 1. Mercury also contributed to the total hazard index in 33 of the approximately 107 risk assessments reporting a total acute hazard index greater than 1, and presented an individual hazard index greater than 1 in 1 of these risk assessments (OEHHA, 1996b).

HEALTH EFFECTS

Probable routes of human exposure to mercury and mercury compounds are inhalation, ingestion, and dermal contact (HSDB, 1991).

Non-Cancer:

Elemental Mercury: Target organs are the brain and kidney. Acute, high level exposure to mercury vapor may cause toxic pneumonitis and pulmonary edema. High acute or chronic overexposure can result in severe central nervous system toxicity, chronic renal disease, and peripheral neuropathies. Children exposed to elemental mercury may develop acrodynia. Acrodynia is a rare syndrome that is characterized by severe leg cramps, irritability, paresthesia, and painful pink fingers and peeling hands, feet, and nose. Mercury salts, but not metallic mercury, are primarily toxic to the kidneys by acute ingestion.

The U.S. EPA has established a Reference Concentration (RfC) of 0.3 micrograms per cubic meter ($\mu g/m^3$) for elemental mercury. The U.S. EPA estimates that inhalation of this concentration or less, over a lifetime, would not likely result in the occurrence of chronic, non-cancer effects (Sittig, 1991; U.S. EPA, 1994a).

Studies on the reproductive and developmental effects of elemental mercury in humans have shown mixed results. An association between mercury exposure and miscarriages was not

observed in one study, while another revealed an increase in the rate of spontaneous abortions. Another study showed a higher than expected frequency of birth defects, which was not confirmed in a fourth study (U.S. EPA, 1994a). Mercury and mercury compounds are listed by the State of California under Proposition 65 as developmental toxicants (CCR, 1996).

Alkyl Mercury Compounds (organic mercury): Alkyl mercury compounds are well absorbed by all routes. The central nervous system, including the brain, is the principal target tissue for this group of toxic compounds. Alkyl mercury compounds readily crosses the blood-brain barrier and placenta. High acute or chronic overexposure may cause kidney damage, organic brain disease, and peripheral neuropathy. The primary effect from chronic exposure to methyl mercury in humans is damage to the central nervous system. The earliest effects are symptoms such as paresthesia, blurred vision, and malaise. Effects at higher doses include deafness, speech difficulties, and constriction of the visual field (Sittig, 1991; U.S. EPA, 1994a).

A chronic non-cancer Reference Exposure Level (REL) of 1 $\mu g/m^3$ is listed for methyl mercury in the California Air Pollution Control Officers Association Air Toxics "Hot Spots" Program, Revised 1992 Risk Assessment Guidelines. The toxicological endpoint considered for chronic toxicity is the central or peripheral nervous system (CAPCOA, 1993). The U.S. EPA has established an oral Reference Dose (RfD) of 3×10^{-4} milligrams per kilogram per day for methyl mercury based on central nervous system effects in humans. The U.S. EPA estimates that consumption of this dose or less, over a lifetime, would not likely result in the occurrence of chronic, non-cancer effects.

Infants born to women who have ingested high levels of methyl mercury have exhibited mental retardation, ataxia, constriction of the visual field, blindness, and cerebral palsy. At lower concentrations, developmental delays and abnormal reflexes were noted (U.S. EPA, 1994a). The State of California has determined under Proposition 65 that methyl mercury is a developmental toxicant (CCR, 1996).

Inorganic Mercuric Compounds: Mercuric chloride is one of the most toxic salts of mercury. Mercuric chloride causes damage to the kidneys and nervous system. Symptoms may include oliguria, anuria, acute renal failure, weak pulse, seizures, psychic disturbances, circulatory collapse, chest pain, and dyspnea (Sittig, 1991). Children exposed to inorganic mercury compounds may develop acrodynia. Acrodynia is a rare syndrome that is characterized by severe leg cramps, irritability, paresthesia, and painful pink fingers and peeling hands, feet, and nose. The primary effect from chronic exposure to inorganic mercury is kidney damage, primarily due to mercury-induced autoimmune glomerulonephritis (induction of an immune response to the body's kidney tissue) (U.S. EPA, 1994a).

An acute non-cancer REL of 30 $\mu g/m^3$ for inorganic mercury and a chronic REL of 0.3 $\mu g/m^3$ for inorganic mercury and mercury compounds are listed in the CAPCOA Air Toxics

"Hot Spots" Program, Revised 1992 Risk Assessment Guidelines. The toxicological endpoints considered for chronic toxicity are the cardiovascular or blood system, central or peripheral nervous system, kidney, gastrointestinal system and liver, and respiratory system. The targets for acute toxicity are the central nervous system, kidney and liver (CAPCOA, 1993).

No information is available on the reproductive or developmental effects of inorganic mercury in humans. Animal studies have reported effects including alterations in testicular tissue, increased resorption rates, and abnormalities of development (U.S. EPA, 1994a). The State of California under Proposition 65 has determined that mercury and mercury compounds are developmental toxicants (CCR, 1996).

Cancer: The human studies available regarding elemental mercury and cancer are inconclusive due to lack of valid exposure data and confounding factors. No studies are available on the carcinogenic effects of methyl mercury in humans. One available animal study reported renal tumors in mice. A chronic study on mercuric chloride in rats and mice reported an increased incidence of forestomach and thyroid tumors in rats, and an increased incidence of renal tumors in mice (U.S. EPA, 1994a).

The U.S. EPA has placed inorganic and methyl mercury in Group C: Possible human carcinogen; and elemental mercury in Group D: Not classifiable as a carcinogen (U.S. EPA, 1994a). The International Agency for Research on Cancer has placed methyl mercury compounds in Group 2B: Possible human carcinogen, and metallic mercury and inorganic mercury compounds in Group 3: Not classifiable (IARC, 1987a). The State of California has determined under Proposition 65 that methyl mercury compounds are carcinogens (CCR, 1996).